# Chapter 915 Roundabouts



## 915.01 General

Modern roundabouts are circular intersections at grade. They can be an effective intersection type with fewer conflict points, lower speeds, and provide for easier decision making than conventional intersections. They require less maintenance than traffic signals. When well designed, they have been found to reduce fatal and severe injury accidents, traffic delays, fuel consumption, and air pollution. They also can have a traffic calming effect. For additional information and details on roundabouts, see *Roundabouts: An Informational Guide*.

Selection of a roundabout as the preferred intersection type is based on several factors including traffic volume, pedestrian and bicycle volume, space requirements, right of way availability, and traffic speeds. The safety benefits of a roundabout decrease with higher traffic volumes, particularly when pedestrians and bicycles are considered. Select a roundabout only when it is clearly the best intersection type.

Modern roundabouts differ from the old rotaries and traffic circles in three important respects: they have a smaller diameter that constrains circulating speeds; they have raised splitter islands that provide entry deflection, slowing down the entering vehicles; and they have yield at entry, which requires entering vehicles to yield, thus allowing circulating traffic free flow.

Old rotaries and traffic circles are characterized by a large diameter, often in excess of 300 ft. This large diameter typically results in travel speeds within the circulating roadway that exceed 30 mph. They typically provide little or no horizontal deflection of the paths of through traffic. These large diameters also create weaving areas that increase accidents in the circulating roadway. At times, traffic control was imposed on the circulating traffic, such as yield or stop signs that required circulating traffic to yield to entering traffic. In some cases, each entry was controlled with a traffic signal. Circular intersections with any of these features are not an approved intersection type.

### (1) Locations Recommended for Roundabouts

Consider roundabouts at intersections:

- Where stop signs result in unacceptable delays for the crossroad traffic.
- With a high left-turn percentage on one or more legs.
- Where a disproportionately high number of accidents involve crossing or turning traffic.
- Where the major traffic movement makes a turn, for example where a state route or city arterial makes a turn.
- Where traffic growth is expected to be high and future traffic patterns are uncertain.
- Where it is not desirable to give priority to either roadway.
- Where major roads intersect at a wye (Y) or tee (T) intersection or with unusual geometry.

### (2) Locations Where Roundabouts Need Additional Evaluation

The following conditions raise concerns that might make a roundabout less than desirable over other intersection types. With an evaluation that gives equal consideration to other intersection types, roundabouts may be considered:

- On a facility with a functional class of collector or above where any leg has a posted speed of 45 mph or higher.
- Where the grade for any leg exceeds 4%.
- Where traffic flows are unbalanced with higher volumes on one or more approaches.
- Where a major road intersects a minor road and a roundabout would result in unacceptable delays to the major road traffic.
- Where there is considerable pedestrian activity and, due to high traffic volumes, it would be difficult for pedestrians to cross either road. This includes special-need pedestrians such as large numbers of children or elderly.
- Where there is inadequate sight distance.
- Where there is considerable bicycle traffic.
- Where a downstream traffic control device could cause a queue that extends into the roundabout. Examples include traffic signals, signalized pedestrian crossings, railroad crossings, and drawbridges.
- Where a railroad will cross through the roundabout.
- With more than six approach legs.

### *(3) Locations Not Recommended for Roundabouts*

Roundabouts are not recommended at intersections:

- Where a satisfactory geometric design (deflection, diameter, roadway width, or grade for example) cannot be provided.
- Where peak period reversible lanes are required.
- At a single intersection in a network of coordinated traffic signals and spacing prevents progression of the traffic signals.
- Where a signal interconnect system would provide a better level of service.
- Where it is desirable to be able to modify traffic movements via signal timings.
- Where volumes on the major roadway does not provide sufficient gaps for the minor roadway drivers, based on gap acceptance analysis model.

## 915.02 References

Americans with Disabilities Act of 1990 (ADA).

*ADA Accessibility Guidelines* (ADAAG), US Access Board, http://www.access-board.gov/adaag/html/adaag.htm

*Revised Code of Washington* (RCW) 47.05.021, Functional classification of highways.

*Standard Plans for Road, Bridge, and Municipal Construction* (Standard Plans), M 21-01, WSDOT.

*Standard Specifications for Road, Bridge, and Municipal Construction* (Standard Specifications), M 41-10, WSDOT.

*Manual on Uniform Traffic Control Devices for Streets and Highways*, USDOT, FHWA; including the *Washington State Modifications to the MUTCD*, M 24-01, WSDOT (MUTCD), http://www.wsdot.wa.gov/biz/trafficoperations/mutcd.htm

*Local Agency Guidelines* (LAG), M 36-63, WSDOT.

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*A Policy on Geometric Design of Highways and Streets* (Green Book), AASHTO.

*Use of Roundabouts*, ITE Technical Council Committee 5B-17, Feb. 1992.

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Crowthorne, England: Transport and Road Research Laboratory, 1980.

*Roundabout Design Guidelines*; Ourston & Doctors, Santa Barbara, California, 1995.

*The Design of Roundabouts. State of the Art Review*; Brown, Mike; Transportation Research Laboratory, Department of Transport. London, HMSO, 1995.

*Crash Reductions Following Installation of Roundabouts in the United States*, Insurance Institute for Highway Safety, March 2000.

ARCADY (Assessment of Roundabout CApacity and DelaY) program, developed by MVA Systematica under contract to Transport Road Research Laboratory (TRRL).

RODEL (ROundabout DELay) program, developed by the Highway Department of Staffordshire County Council in the UK.

aaSIDRA (Signalized Intersection Design and Research Aid) program, developed by The Australian Road Research Board (ARRB).

## 915.03 Definitions

***approach roadway*** The lane or set of lanes for traffic approaching the roundabout. (See Figure 915-1.)

***central island*** The area of the roundabout surrounded by the circulating roadway.

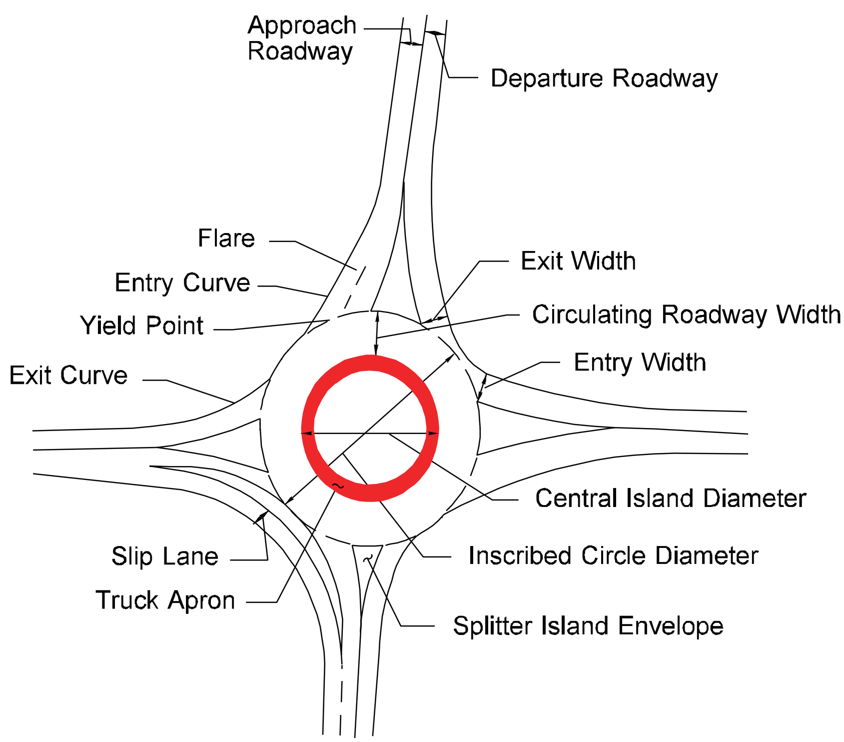
***central island diameter*** The diameter of the central island, including the truck apron. (See Figure 915-1.)

***circulating lane*** A lane used by vehicles circulating in the roundabout.

***circulating roadway width*** The width of the area within the inscribed circle for vehicular movement measured from inscribed circle to the central island. (See Figure 915-1.)

***conflict*** An event involving two or more road users in which the action of one user causes the other user to make an evasive maneuver to avoid a collision.

***curb bulb*** A bulge in a curb line that reduces the width of the roadway.




**Roundabout Elements**
*Figure 915-1*

***deflection*** The change in the path of a vehicle imposed by geometric features of a roundabout resulting in a slowing of vehicles. (See Figures 915-9a and 9b.)

***departure roadway*** The lane or set of lanes for traffic leaving the roundabout. (See Figure 915-1.)

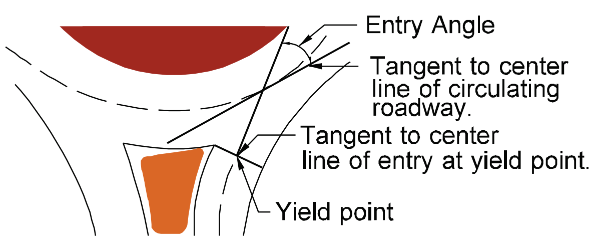
***design speed*** The speed used to determine the various geometric design features of the roadway.

***design vehicle*** A vehicle, the dimensions and operating characteristics of which are used to establish the layout geometry.

***detectable warning surface*** A feature of a walking surface to warn visually impaired pedestrians of a hazard. Truncated domes are specified by The ADAAG.

***double-lane roundabout*** A roundabout with the circulating roadway and one or more entry or exit legs designed as two lanes.

***entry angle*** The angle between the entry roadway and the circulating roadway measured at the yield point. (See Figure 915-2.)




**Entry Angle**
***Figure 915-2***

***entry curve*** The curve of the right curb that leads vehicles into the circulating roadway. (See Figure 915-1.)

***entry width*** The width of an entrance leg at the inscribed circle. (See Figure 915-1.)

***exit curve*** The curve of the right curb that leads vehicles out of the circulating roadway. (See Figure 915-1.)

***exit width*** The width of an exit leg at the inscribed circle. (See Figure 915-1.)

***flare*** The widening of the approach to the roundabout to increase capacity. (See Figure 915-1.)

***functional classification*** The grouping of streets and highways according to the character of the service they are intended to provide as provided in RCW 47.05.021.

***inscribed circle*** The entire area within a roundabout between all of the approaches and exits.

***inscribed circle diameter*** The diameter of the inscribed circle. (See Figure 915-1.)

***intersection angle*** The angle between any two intersection legs at the point that the center lines intersect.

***intersection at grade*** The general area where a roadway or ramp terminal is met or crossed at a common grade or elevation by another roadway.

***intersection leg*** Any one of the roadways radiating from and forming part of an intersection.

***intersection sight distance*** The sight distance for the driver of a vehicle on the crossroad along the main roadway, as compared to the distance required for safe operation.

***island*** A defined area within an intersection, between traffic lanes, for the separation of vehicle movements or for pedestrian refuge.

***lane*** A strip of roadway used by a single line of vehicles.

***lane width*** The lateral design width for a single lane, striped as shown in the Standard Plans and the Standard Specifications. The width of an existing lane is measured from the edge of traveled way to the center of the lane line or between the centers of successive lane lines.

***roadway*** The portion of a state highway; a federal, county, or private road; or a city street, including shoulders, for vehicular use.

***roundabout*** A circular intersection with yield control of all entering traffic, channelized approaches with raised splitter islands, counter-clockwise circulation, and appropriate geometric curvature to ensure that travel speeds on the circulating roadway are typically less than 30 mph.

***sight distance*** The length of roadway visible to the driver.

***single-lane roundabout*** A roundabout with the circulating roadway and all entry and exit legs designed as one lane.

***shoulder*** The portion of the roadway contiguous with the traveled way, primarily for accommodation of stopped vehicles, emergency use, lateral support of the traveled way, and use by pedestrians and bicycles.

***slip lane*** A lane that separates heavy right turn movements from the roundabout circulating traffic. (See Figure 915-1.)

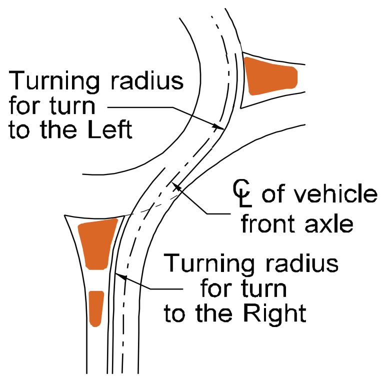
***splitter island*** The raised island at each two-way leg between entering vehicles and exiting vehicles, designed primarily to deflect entering traffic.

***splitter island envelope*** The raised splitter island and the painted channelization surrounding it. (See Figure 915-1.)

***stopping sight distance*** The sight distance, as compared to the distance required to detect a hazard and safely stop a vehicle traveling at design speed.

***superelevation*** The rotation of the roadway cross section in such a manner as to overcome part of the centrifugal force that acts on a vehicle traversing a curve.

***rural area*** A nonurban area.




**Turning Radius (R)**
***Figure 915-3***

***truck apron*** The optional, outer, mountable portion of the central island of a roundabout between the raised, nontraversable area of the central island and the circulating roadway. (See Figure 915-1.)

***turning radius*** The radius that the front wheel of the design vehicle on the outside of the curve travels while making a turn. (See Figure 915-3.)

***urban area*** One of the following areas:

- Within the federal urban area boundary as designated by FHWA.
- Characterized by intensive use of the land for the location of structures and receiving such urban services as sewers, water, and other public utilities and services normally associated with urbanized areas.
- With not more than twenty-five percent undeveloped land.

***yield-at-entry*** The requirement that vehicles on all approaches yield to vehicles within the circulating roadway.

***yield point*** The point of entry from an approach into the circulating roadway. If necessary, entering traffic must yield to circulating traffic at this point before entering the circulating roadway. (See Figure 915-1.)

## 915.04 Roundabout Categories

Roundabouts have been categorized according to size and environment to facilitate discussion of specific performance or design issues. There are six basic categories based on environment, number of lanes, and size:

- Mini roundabouts
- Urban compact roundabouts
- Urban single-lane roundabouts
- Urban double-lane roundabouts
- Rural single-lane roundabouts
- Rural double-lane roundabouts

Characteristics of the different roundabout categories are summarized on Figure 915-7. These categories and Figure 915-7 represent general characteristics of roundabouts, not design limits. Final design values may vary.

Separate categories have not been identified for suburban environments. Suburban settings combine higher approach speeds common in rural areas with multimodal activity that is more similar to urban settings. Therefore, generally, design suburban roundabouts as urban roundabouts but with the high-speed approach treatments recommended for rural roundabouts.

### *(1) Mini Roundabouts*

Mini roundabouts are small roundabouts used in low-speed urban environments and are not suitable for use on a state route. They can be useful in low-speed urban environments, with average operating speeds of 35 mph or less, where a conventional roundabout is precluded by right of way constraints. In retrofit applications, mini roundabouts are relatively inexpensive because they typically require minimal additional pavement at the intersecting roads. They are mostly recommended when there is insufficient right of way for an urban compact roundabout. Because they are small, mini roundabouts are perceived as pedestrian friendly with short crossing distances and very low vehicle speeds on approaches and exits. The mini roundabout is designed to accommodate passenger cars without requiring them to drive over the central island. A mountable central island is recommended because larger vehicles might be required to cross over it. Provide speed control around the mountable central island in the design by requiring horizontal deflection. Capacity for this type of roundabout is expected to be similar to that of the urban compact roundabout. Permeable pavement might be appropriate in the mountable center island to offset any storm water impacts.

### *(2) Urban Compact Roundabouts*

Urban compact roundabouts are also intended to be pedestrian and bicyclist friendly. Because of the smaller design vehicle, they are normally not suitable for use on a state route. Their perpendicular approach legs require very low vehicle speeds. All legs have single-lane entries. However, the urban compact treatment meets all the design requirements of effective roundabouts. The principal objective of this design is to enable pedestrians to have safe and effective use of the intersection. Consider urban compact roundabouts only where capacity is not a critical issue. The geometric design includes raised splitter islands that incorporate at-grade pedestrian storage areas, and a nonmountable central island. There is usually a truck apron surrounding the compact central island to accommodate large vehicles.

### *(3) Urban Single-Lane Roundabouts*

Urban single-lane roundabouts are characterized as having single-lane entries at all legs and one circulating lane. They are distinguished from urban compact roundabouts by their larger inscribed circle diameters and more tangential entries and exits, resulting in higher capacities. Their design allows slightly higher speeds at the entry, on the circulating roadway, and at the exit. This roundabout design is focused on achieving consistent entering and circulating vehicle speeds. The geometric design includes raised splitter islands, a nonmountable central island, and (preferably) no apron. However, a truck apron might be necessary to allow large trucks to make left turns. When a truck apron is used, design the roundabout so that a bus will not need to use it.

### *(4) Urban Double-Lane Roundabouts*

Urban double-lane roundabouts include all roundabouts in urban areas that have at least one entry with two lanes. They include roundabouts with entries on one or more approaches that flare from one to two lanes. These require wider circulating roadways to accommodate two vehicles traveling side by side. The speeds at the entry, on the circulating roadway, and at the exit are similar to those for the urban single-lane roundabouts. It is important that the vehicular speeds be consistent throughout the roundabout. Geometric design includes raised splitter islands, a nonmountable central island, and appropriate horizontal deflection.

Alternate routes may be provided for bicyclists who choose to bypass the roundabout. Delineate bicycle and pedestrian pathways clearly. Use sidewalks and landscaping to direct users to the appropriate crossing locations and alignment. Urban double-lane roundabouts located in areas with high pedestrian or bicycle volumes might have special design requirements.

When a double-lane roundabout is required for the design year but traffic projections indicate that one lane will be sufficient for 10 years or more, consider restricting it to one lane until traffic volumes require a double-lane roundabout.

### *(5) Rural Single-Lane Roundabouts*

Rural single-lane roundabouts generally have high approach speeds. They require supplementary geometric and traffic control device treatments on approaches to encourage drivers to slow to an appropriate speed before entering the roundabout. Rural roundabouts may have larger diameters than urban roundabouts to allow slightly higher speeds at the entries, on the circulating roadway, and at the exits. This is possible if current and anticipated future pedestrian volumes are low.

Design rural roundabouts that might become part of an urban area with slower speeds and pedestrian treatments. However, in the interim, provide supplementary approach and entry features to achieve safe speed reduction. Supplemental geometric design elements include extended and raised splitter islands, a nonmountable central island, and adequate horizontal deflection.

The central island needs to have “target value” to give cues to approaching drivers that there is something that they must drive around. Designers will need to mound the planting area and plant native materials that are out of clear zone and provide “target value”.

The geometric design includes a truck apron where necessary for WB-50 and larger trucks to use the roundabout. Design the roundabout so that a WB-40 will not be required to use the truck apron.

### *(6) Rural Double-Lane Roundabouts*

Rural double-lane roundabouts have speed characteristics similar to rural single-lane roundabouts. They differ in having two entry lanes, or entries flared from one to two lanes, on one or more approaches. Consequently, many of the characteristics and design features of rural double-lane roundabouts mirror those of their urban counterparts. The main design differences are higher entry speeds and larger diameters, and recommended supplementary approach treatments. Design rural roundabouts that might become part of an urban area for slower speeds, with design details that fully accommodate pedestrians and bicyclists. However, in the interim, design approach and entry features to achieve safe speed reduction.

The central island needs to have “target value” to give cues to approaching drivers that there is something that they must drive around. Designers will need to mound the planting area and plant native materials that are out of clear zone and provide “target value”.

When a double-lane roundabout is required for the design year but traffic projections indicate that one lane will be sufficient for at least 5 to 10 years, consider restricting it to one lane until traffic volumes require a double-lane roundabout.

## 915.05 Capacity Analysis

A capacity analysis is required for each proposed roundabout to compare it to other types of intersection control.

Design roundabouts so that the demand volume to capacity ratio is 0.85 or less and the anticipated delays are comparable to other types of intersection control.

There are two methods of performing the capacity analysis:

- An analysis based on gap acceptance (the Australian method). Use the method given in the *Austroad Guide* or the *Highway Capacity Manual*.
- An empirical formula based on measurements at a saturated roundabout (the British method). Use the method given in TRRL Report 942.

While each method has advantages, it is felt there is currently not enough United States performance data on which to base the empirical method analysis. Therefore, the gap acceptance method is preferred.

Figure 915-8 may be used to estimate the entry capacity of each roundabout entry leg; however, perform a capacity analysis using other methods to verify roundabout capacity.

## 915.06 Geometric Design

### (1) Design Vehicle

The physical characteristics of the design vehicle are one of the elements that control the geometric design of a roundabout. See Chapter 910 for guidance on the selection of a design vehicle. As with other intersections, the design vehicle may differ for each movement. Use the largest vehicle selected for any movement as the design vehicle for the circulating roadway. For a roundabout on a state highway, this is the WB-50 vehicle. Design a roundabout so that the design vehicle can use it with 2 ft clearance from the turning radius to any curb face. The rear wheel of a semitrailer may encroach on the truck apron.

It is desirable to design the circulating roadway so that a BUS design vehicle in urban areas and a WB-40 in rural areas can use the roundabout without encroaching on the truck apron.

Design roundabouts on state routes so the WB-67 can use it without leaving the truck apron or encroaching on a curb. Use vehicle turning path templates to verify that this vehicle can make all state highway to state highway movements.

The vehicle path through a roundabout will normally contain reverse or compound curves. To check the roundabout for the design vehicles, a computer generated template for each path is recommended.

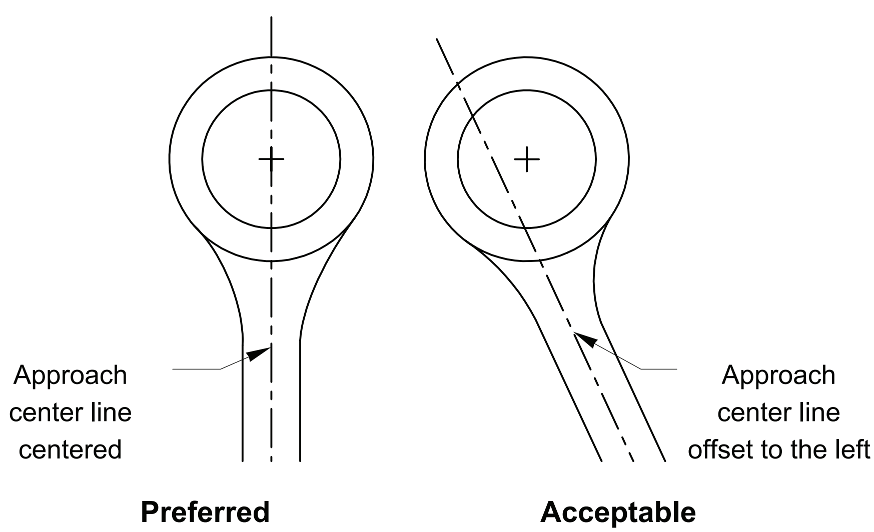
### (2) Approach Alignment

The preferred alignment of an approach leg to a roundabout is with the centerline passing through the center of the inscribed circle. (See Figure 915-4.) This allows the roundabout to be designed so that vehicles will maintain slow speeds at both the entries and the exits. This alignment makes the central island more conspicuous to approaching drivers.

Where it is not possible to align an approach leg through the center of the inscribed circle, a slight offset to the left is acceptable. (See Figure 915-4.) This will allow adequate curvature at the entry, which is of greatest importance. In some cases, it may be beneficial to offset the approach slightly to the left to enhance the entry curvature. However, this will create a more tangential exit with increased exit speed and might increase the risk for pedestrians.

Approach alignment offset to the right of the roundabout's center point is unacceptable. This alignment

It is desirable to equally space the angles between entries. This will optimize the separation between successive entries and exits. When site conditions make equal spacing impractical, spacing may be varied to a minimum of 40°. When reducing the angle between approaches, ensure that speed consistency [915.06(4)] is maintained.




**Approach Leg Alignment**
*Figure 915-4*

### (3) Deflection and Design Speed

For a roundabout to work properly, it must be designed to reduce the relative speeds between conflicting traffic streams. The most significant feature that will control the speed is adequate deflection. The deflection is expressed as the radius of the center line of a vehicle path through the roundabout. Figures 915-9a and 9b illustrate the vehicle paths for determining deflection.

The vehicle path can be adjusted by:

- Changing the alignment and width of the entry and the shape, size, and position of the approach splitter island.
- Changing the central island size.
- Staggering alignment between entrance and exit.

The deflection design speed is controlled by the path radius and cross slope of the roadway. Figure 915-5 gives the deflection radii for design speeds for roadways that slope down to the outside of the curve (-2%), that are level (0%), and that slope down to the inside of the curve (2%). Use the following equation to make the final adjustments for speeds between those given:

$$V = \sqrt{\frac{R(c+f)}{6.69}}$$

Where:

$V$ = Design speed in mph

$R$ = The deflection radius in feet.

$c$ = Slope of the roadway in percent

$f$ = Side friction factor from Figure 915-4

Design roundabouts so that deflection limits the entry speed to 30 mph or less and achieves speed consistency. In areas with a large number of pedestrians or bicyclists, design roundabouts for a maximum speed of 15 to 20 mph.

| Design Speed (mph) | Deflection Radius (ft) Cross Slope | | | Side Friction actor $f$ |
|---|---|---|---|---|
| | -2% | 0% | 2% | |
| 10 | 20 | 20 | 20 | 38 |
| 15 | 50 | 50 | 45 | 32 |
| 20 | 110 | 100 | 95 | 27 |
| 25 | 200 | 185 | 170 | 23 |
| 30 | 335 | 300 | 275 | 20 |
| 35 | 515 | 455 | 410 | 18 |

**Deflection**
***Figure 915-5***

### (4) Speed Consistency

Speed consistency for all movements is an important element of roundabout design. Speed consistency is achieved when the differences between speeds of paths that merge, cross, or parallel each other do not exceed 12 mph.

Figure 915-10 shows five critical path radii to be checked for each leg. The entry path ($R_1$) is the minimum radius for through traffic approaching the yield point. The circulating path ($R_2$) is the minimum radius for through traffic around the central island. The exit path ($R_3$) is the minimum radius for through traffic into the exit. The left-turn path ($R_4$) is the minimum radius for the conflicting left-turn movement. The right-turn path ($R_5$) is the minimum radius for a right-turning vehicle. These vehicular path radii are determined as shown on Figures 915-9a and 9b.

Make $R_1$ smaller than or equal to $R_2$, and $R_2$ smaller than or equal to $R_3$ ($R_1 \le R_2 \le R_3$). This ensures that speeds will be reduced to their lowest at the roundabout entry reducing the likelihood of problems in the roundabout.

### (5) Inscribed Diameter

The inscribed diameter is controlled by the space available, the design speed, design vehicle and the number of legs. The size of the inscribed diameter is a balance between designing for large vehicles and providing adequate deflection for the design speed. Select a diameter that will result in a speed at or below the desired design speed.

To meet the need to provide an adequate turning radius, the right-turn movement might require that the inscribed diameter be increased for roundabouts with more than four legs or with high skew angles. On state routes, make the turning radius 50 ft minimum with 2 ft clearance to the face of a curb.

The inscribed circle is not always circular, with a constant-radius circulating roadway; ovals and tear drops have been used. Noncircular shapes are allowed when the smaller turning radius is at least 50 ft. When a noncircular roundabout is used, where possible align it so that the heavier traffic uses the larger radius.

### *(6) Entry*

Design the entry width to accommodate the design vehicles and required entry lanes while providing adequate deflection. Design the entry so that the entry angle is between 20° and 60°, preferably between 30° and 40°. Figure 915-11 provides additional guidance for entry design.

When the approach width, including shoulders and parking lanes, is wider than needed for the entry width, consider curb bulbs to reduce the width. For information on parking limitation at roundabouts, see 915.11.

When the roundabout is on a state route, the minimum turning radius is 50 ft to provide for large trucks. It is desirable for the entry radius to be smaller than both the circulating radius and the exit radius. This makes the speeds the lowest at the roundabout entry. It also helps to reduce the speed differential between entering and circulating traffic.

Design the entry radius, $R_1$ on Figure 915-10, to limit entry speeds to not more than 25 mph in urban areas and 30 mph in rural area.

At single-lane roundabouts, it is not difficult to reduce the value of the entry radius. The curb radius at the entry can be reduced or the alignment of the approach can be shifted to the left to achieve a slower entry speed. This is more difficult at double-lane roundabouts. When entry and exit curve radii are too small, the natural path of adjacent traffic can overlap. Path overlap occurs when the geometry leads a vehicle in the left lane to cross into the right lane to avoid the central island. (See Figure 915-12.) Path overlap can reduce capacity and increase accidents. Take care when designing double-lane roundabouts to avoid path overlap. For more information on path overlap, see *Roundabouts: An Informational Guide*.

Flaring is an effective means of introducing a double-lane roundabout without requiring as much right of way as a full lane addition. 130 ft is the optimum flare length to add a second lane at a double-lane roundabout. However, if right of way is constrained, shorter flare lengths may be used with decreased capacity.

At rural locations, consider the speed differential between the approaches and entries. If the posted speed of the approach is greater than 15 mph above the design speed of the entry curve, consider introducing speed reduction measures before the entry curve.

### *(7) Circulating Roadway*

Keep the circulating width constant throughout the roundabout with the minimum width equal to or slightly wider (120%) than the maximum entry width.

At single-lane roundabouts, provide a circulating roadway width plus truck apron to just accommodate the design vehicle. Use appropriate vehicle-turning templates or a computer program to determine the swept path of the design vehicle through each turning movement. Provide a minimum clearance of 2 ft between the vehicle's tire track and all vertical curbs with a height of 6 in or more.

Design the circulating radius, $R_2$ on Figure 915-10, to be larger than the entry radius. In some cases where capacity is not a concern, it might not be possible for the circulating radius to be greater than the entry radius. In such cases, the entry radius may be greater than the circulating radius, provided the difference in speeds is less than 12 mph and preferably less than 6 mph.

### *(8) Exit*

Design the exit width to accommodate the design vehicles while providing adequate deflection. Figure 915-11 provides additional guidance for exit design.

Generally, design the exit radius, $R_3$ on Figure 915-10, larger than both the entry radius ($R_1$) and the circulating radius ($R_2$). The larger exit curve radii improve the ease of exit and minimize the likelihood of congestion at the exits. This, however, is balanced by the need to maintain low speeds at the pedestrian crossing on exit. If the exit path radius is smaller than the circulating path radius, vehicles might be traveling too fast to negotiate the exit and crash into the splitter island or into oncoming traffic.

At single-lane roundabouts with pedestrian activity, design exit radii the same as or slightly larger than the circulating radius to minimize exit speeds. However, at double-lane roundabouts, additional care must be taken to minimize the likelihood of exit path overlap. Exit path overlap can occur when a vehicle on the left side of the circulating roadway exits into the right exit lane. Where no pedestrians are expected, make the exit radii large enough to minimize the likelihood of exiting path overlap. Where pedestrians are present, tighter exit curvature might be necessary to ensure low speeds at the pedestrian crossing.

When the departure roadway width, including shoulders and parking lanes, is wider than needed for the exit width, consider curb bulbs to reduce the width.

### *(9) Turning movements*

Evaluate the left- and right-turn radii, $R_4$ and $R_5$ on Figure 915-10, to ensure that the maximum speed differential between entering and circulating traffic is no more than 12 mph. The left-turn movement is the lowest circulating speed. The left-turn radius can be determined by adding 5 ft to the central island radius.

### *(10) Sight Distance*

The operator of a vehicle approaching a roundabout needs to have an unobstructed view of the splitter island, central island, yield point, and sufficient lengths of the intersecting roadways to permit recognition of the roundabout and to initiate the required maneuvers to maintain control of the vehicle and to avoid collisions. To do this, two aspects of the sight distance are necessary:

- **Stopping Sight Distance.** Provide the stopping sight distance given on Figure 915-6 at all points on the approach roadways, the circulating roadway, and the departure roadways. Check each vehicle path using the deflection speed. See Chapter 650 for additional information on stopping sight distance.

| Speed (mph) | Stopping Sight Distance (ft) |
|---|---|
| 10 | 47 |
| 15 | 77 |
| 20 | 113 |
| 25 | 153 |
| 30 | 198 |
| 35 | 248 |

**Stopping Sight Distance for Roundabouts**
*Figure 915-6*

- **Intersection Sight Distance.** For intersection sight distance at roundabouts, provide a clear view of traffic on the circulating roadway and approaching the roundabout on the leg to the left for a distance equal to that traveled in 4.5 seconds. The required gap is also a function of capacity and, at lower volumes, a larger gap may be required. However, do not use an intersection sight distance (Figure 915-13) less than the stopping sight distance (Figure 915-6).

  Because traffic is approaching a yield condition and might not be required to stop before entering a roundabout, provide the sight distance along the approach for 50 ft. Momentary sight obstructions that do not hide a vehicle, such as poles, sign posts, and narrow trees, are acceptable in the sight triangles including the central island. Guidance for intersection sight distance at a roundabout is shown on Figure 915-13.

Providing adequate sight distance will also provide clear zone for the central island.

### (11) Islands

Raised islands are important for effective operation of a roundabout. Their primary purpose is to control deflection.

(a) **Central Island**. The central island is a raised, nontraversable area and may include a truck apron (Figure 915-14). The truck apron is the outer part of the central island, designed to allow for encroachment by the rear wheels of large trucks.

The primary control of the central island size is the inscribed diameter, the required circulating width, and the required deflection. When the required circulating width for the large vehicles results in a deflection radius larger than the maximum for the design speed, increase the central island diameter to achieve the desired deflection radius and provide a truck apron. Make the surfacing of the truck apron different from the circulating roadway. However, make the surfacing of the apron different from the sidewalks so that pedestrians are not encouraged to cross the circulating roadway. Use a 3 in mountable curb between the circulating roadway and the truck apron.

Use a 6 in or higher vertical curb between the truck apron and the nontraversable area. Landscape or mound the raised, nontraversable area to improve the visual impact of the roundabout to approaching drivers. When designing landscaping, consider sight distance and roadside safety. Also, consider maintenance needs for access to the landscaping in the central island.

When designing the landscaping for the central island, do not use items that might tempt people to take a closer look. Do not place street furniture or other objects that may attract pedestrian traffic to the central island, such as benches or monuments with small text. Design fountains or monuments in the central island in a way that will enable proper viewing from the perimeter of the roundabout. In addition, design and locate all objects in the center island to maintain sight distance, minimize driver distraction, and minimize the possibility of impact from an errant vehicle.

(b) **Splitter Island**. Splitter islands are built at each two-way leg. They serve to:

- Control the entry and exit speeds by providing deflection.
- Prevent wrong way movements.
- Provide pedestrian refuge.
- Provide a place to mount signs.

The desirable length of a splitter island envelope is equal to the stopping sight distance for the design speed of the roadway approaching the roundabout. (See Chapter 650.) Make the extensions of the curves that form the splitter islands tangent to the outside edge of the central island. The minimum width of the island at any crosswalk is 6.5 ft. Figure 915-15 gives guidance on the design of splitter islands.

For information on shoulders at islands, island nose radii, nose offsets, and other details, see Chapter 910.

### (12) Grades and Superelevation

It is preferred that the grade on all of the intersecting roadways at a roundabout is 4% or flatter and that the grades be constant through the roundabout or that the roundabout be in a sag vertical curve. Grade in excess of 4% can result in reduces sight distance, increased difficulty slowing or stopping, and higher possibility of vehicle rollover.

When a roundabout must be built at or near the crest of a vertical curve on one of the roadways, pay special attention to the sight distances. For additional information on grades at roundabouts, see *Roundabouts: An Informational Guide*.

Do not use superelevation for the circulating roadway. It is desirable to maintain the normal 2% cross slope from the central island to the outside of the circle. (See Figure 915-5) This will improve drainage and help reduce the speed of circulating traffic.

### (13) Right-Turn Slip Lane

Right-turn slip lanes may be used, with justification, when a right-turn movement is heavy enough to lead to a breakdown in roundabout operation and the radius produces a speed comparable to the speed through the roundabout.

For additional information on channelization for right-turn slip lanes, see right turn lanes at islands in Chapter 910 and *Roundabouts: An Informational Guide*.

### *(14) Design Clear Zone*

For the right side of the circulating roadway, see Chapter 700 using the $R_2$ speed for the required design clear zone. Do not place light standards or other poles without breakaway features in splitter islands or on the right side just downstream of an exit point. When any approach leg has a posted speed of 45 mph or higher, place no fixed object, water features with a depth of 2 ft or more, or other hazards in the central island. At roundabouts with all approach legs posted at 40 mph or less, avoid water features with a depth of 2 ft or more in the central island. Avoid fixed objects in central islands when the island diameter is less than 65 ft. Within the central island, clear zone is desirable to provide both a recovery area for errant vehicles and sight distance. When necessary to protect features in the central island, provide a central island low profile barrier 18 in high or higher.

## 915.07 Pedestrians

Pedestrian crossings are unique at roundabouts in that the pedestrian is required to cross at a point behind the vehicles entering the roundabout. The normal crossing point at intersections is in front of these vehicles. For this reason, mark all pedestrian crosswalks at urban roundabouts and at rural roundabouts when pedestrian activity is anticipated. Position the crosswalk one car length, approximately 20 ft, from the yield point and use the raised splitter island as a pedestrian refuge. (See Figures 915-15 and 16.) Consider landscaping strips to discourage pedestrians crossing at undesirable locations.

Provide a barrier-free passageway at least 6 ft wide, 10 ft desirable, through this island for persons with disabilities. Whenever a raised splitter island is provided, also provide pedestrian refuge. This facilitates the pedestrian crossing in two separate movements.

Give special attention to assisting pedestrians who are visually impaired through design elements such as providing tactile cues through the installation of truncated domes at curb ramps, splitter islands, and any other pedestrian facility that might lead to conflicts with pedestrians and vehicular traffic. These pedestrians typically attempt to maintain their approach alignment to continue across a street in the crosswalk. A roundabout requires deviation from that alignment. Provide appropriate informational cues to pedestrians regarding the location of the sidewalk and the crosswalk.

See Chapter 1025 for sidewalk ramps and additional information on pedestrian needs.

## 915.08 Bicycles

The operating speed of vehicles within smaller low speed roundabouts is, in most cases, the same speed as that of bicyclists and both can use the same roadway without conflict or special treatment. Larger roundabouts with higher operating speeds can present problems for the bike rider and an alternate bike path, a shared use sidewalk, or warning signs might be necessary. If the bike riders are children, as in the case of a nearby elementary school, consider signing and pavement markings directing them to use the adjacent sidewalk. End all bicycle lanes before they enter a roundabout, with the bicycles either entering traffic to use the circulating roadway or leaving the roadway on a separate path or a shared use sidewalk. See Figure 915-16 for the recommended design for ending a bicycle lane with a shared use sidewalk at a roundabout.

## 915.09 Signing and Pavement Marking

Roundabouts, being a new concept in Washington State, require consistent signing and pavement markings to familiarize motorists with their intended operation.

Roundabout signing is shown on Figure 915-17. Locate signs where they have maximum visibility for road users but a minimal likelihood of obscuring other signs, pedestrians, or bicyclists. Use only signs contained in the MUTCD. A diagrammatic guide sign, as shown in the figure, can be used to provide the driver with destination information. Provide a route confirmation sign on all state routes shortly after exiting the roundabout.

Pavement markings are shown in the MUTCD. Optional lane lines between lanes within the circulating roadway may be used on multilane roundabouts. When evaluating whether or not to provide lane lines within the circulating roadway, consider the following potential impacts:

- Reduce confusion
- Reduce flexibility
- Improve lane alignment
- Reduce capacity
- Provide a more normal situation
- Might require advanced signing for proper lane usage at the entry

When lane lines are to be used, include the striping plan with the roundabout approval request.

## 915.10 Illumination

For a roundabout to operate satisfactorily, a driver must be able to enter, move through, and exit the roundabout in a safe and efficient manner. To accomplish this, a driver must be able to see the layout and operation in time to make the appropriate maneuvers. Adequate lighting is needed for this at night.

Provide illumination for roundabouts with any one of the following:

- At least one leg is a state route or ramp terminal.
- It is necessary to improve the visibilityof pedestrians and bicyclists.
- One or more of the legs are illuminated.
- An illuminated area in the vicinity can distract the driver's view.
- Heavy nighttime traffic is anticipated.

Provide illumination for each of the conflict points between circulating and entering traffic in the roundabout and at the beginning of the raised splitter islands. Figure 915-18 depicts the light standard placement for a four-legged roundabout. See Chapter 840 for additional information and requirements on illumination. A single light source located in the central island is not acceptable. When one or more of the legs are illuminated, provide a light level within the roundabout approximately 50% higher than the highest level on any leg. Use a high pressure sodium vapor luminaire with a medium or short cut-off light distribution for the light source. Position the luminaire over the outside edge of the roundabout to use the "house side" lighting to illuminate the pedestrian crosswalks.

## 915.11 Access, Parking, and Transit Facilities

No road approach connections to the circulating roadway are allowed at roundabouts, unless it is designed as a leg to the roundabout appropriate for the traffic volume using the approach. Road approach connections to the circulating roadway are allowed only when no other reasonable access is available. It is preferred that road approaches not be located on the approach or departure legs within the length of the splitter island. The minimum distance from the circulating roadway to a road approach is controlled by the corner clearance using the circulating roadway as the crossroad. (See Chapter 1435.)

Parking is not allowed in the circulating roadway or on the approach roadway past the crosswalk. It is also desirable that no parking be allowed on the approach or departure legs for the length of the splitter island. See Chapter 1025 for additional information on parking limitations near a crosswalk.

Transit stops are not allowed in the circulating roadway or on the approach roadway past the crosswalk. Locate transit stops on departure legs in a pullout or where the pavement is wide enough that a stopped bus will not block the through movement of traffic. Locate transit stops on approach or departure legs where they will not obstruct sight distance.

## 915.12 Procedures

### *(1) Selection*

Use the following steps when selecting a roundabout for intersection control:

(a) Consider the context. Are there constraints that must be addressed? Are there site-specific and community impact reasons why a roundabout of a particular size would not be a good choice?

(b) Determine the roundabout category (Figure 915-7) and a preliminary lane configuration (Figure 915-8) based on capacity requirements.

(c) Identify the justification category. See 915.12(2). This establishes why a roundabout might be the preferred choice and determines the need for specific information.

(d) Perform the analysis appropriate to the selection category. If the selection is to be based on operational performance, use the appropriate comparisons with alternative intersections

(e) Determine the right of way requirements and feasibility.

(f) If additional right of way must be acquired or alternative intersection forms are viable, an economic evaluation will be useful.

(g) Contact all approving authorities to obtain concurrence that a roundabout is an acceptable concept at the proposed location. On state routes this includes the HQ Design Office.

### *(2) Justification*

Consider roundabouts only when fulfilling one or more of the following justification categories:

(a) **Safety Improvement.** At high accident location intersections, a roundabout might be a method of reducing accidents by reducing the number of conflict points. At conventional intersections, many accidents involve left-turning or crossing vehicles; with roundabouts these movements are eliminated. With the low operating speeds and low entry angles, accidents at roundabouts are generally less severe.

Roundabouts in this category require an accident analysis that shows high accidents of a type that a roundabout can reduce in number or severity. In the analysis, consider any potential shift of accidents to another accident type.

(b) **Improve Intersection Capacity.** A roundabout may be analyzed as an alternative to traditional traffic control options to increase the capacity of an intersection. With traffic signals, alternating traffic streams through the intersection can cause a loss of capacity when the intersection clears between phases. In a roundabout, vehicles may enter available gaps simultaneously from multiple approaches. This can result in an advantage in capacity. This advantage becomes greater when the volume of left turning vehicles is high.

Justify roundabouts in this category with a capacity analysis showing that it can provide the required capacity comparable to the optimum design for a conventional intersection. Discuss the effects on “off-peak” traffic.

(c) **Queue Reduction.** Roundabouts can improve operations at locations where the space for queuing is limited. Roadways are often widened for queuing at traffic signals, but the reduced delays and continuous flows at roundabouts allow the use of fewer lanes. Possible applications are at interchanges where left turn volumes are high. Roundabouts at ramp terminals can improve capacity without widening a structure.

Roundabouts in this category require an analysis showing that the roundabout will eliminate the need to build additional lanes or widen a structure without additional impacts to the main line operations.

(d) **Special Conditions.** The special conditions where a roundabout might be preferred over a conventional intersection include locations with unusual geometrics; right of way limitations; closely spaced intersections; wye (Y) intersections; and, on nonstate routes, for traffic calming. Roundabouts might be better suited for intersections with unusual geometrics; such as high skew angle and offset legs. Roundabouts can provide adequate levels of operation without significant realignment or complicated signing or signal phasing.

Roundabouts can avoid the need to obtain additional right of way along the intersection legs. Roundabouts can shift any required right of way from the roadway between the intersections to the area of the intersection.

Roundabouts can eliminate closely spaced intersections, and any associated operational problems, by combining them into one intersection. The ability of roundabouts to serve high turning volumes make them a practical design at wye (Y) or tee (T) intersections.

Roundabouts proposed for a special condition require documentation indicating what the condition is and how the roundabout will address it.

### *(3) Approval*

A proposal to install a roundabout on any route, either NHS or non-NHS, with a posted speed limit of 45 mph or higher requires an analysis of alternatives. See Chapter 910 for requirements.

HQ Design Office approval of the design is required when a roundabout is to be used on a state highway. Submit to the HQ Design Office:

- Supporting engineering data.
- Concurrence that a roundabout is an acceptable concept 915.12(1)(g).
- An intersection plan.
- Roundabout justification from 915.12 (2).
- A comparison of the roundabout to alternative intersection types with an explanation as to why the roundabout is the preferred alternative.
- A traffic analysis of the roundabout and alternative intersection types, including a discussion of any loss in level of service or increase in delay. Include the effects on "off-peak" traffic and discuss any adverse impacts of the roundabout.
- An analysis of pedestrian and bicycle activities.
- An approved analysis of alternatives for roundabouts on any state route with a posted speed of 45 mph or higher.
- The approval of the State Design Engineer or designee for roundabouts within the limits of limited access control.
- The calculated design speeds for the entry path, the circulating path, the exit path, the left-turn path, and the right-turn path for each leg of the roundabout.
- A corridor and network analysis.
- Current or projected traffic control or safety problems at the roundabout.
- Demonstration that the proposed configuration can be implemented and that it will provide adequate capacity on all approaches.
- All potential complicating factors, their relevance to the location, and any mitigation efforts that might be required.
- An economic analysis, indicating that a roundabout compares favorably with lternative control modes from a benefit-cost perspective.

## 915.13 Documentation

A list of the documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following web site: http//www.wsdot.wa.gov/eesc/design/projectdev/

| | Design Element | Mini (1) | Urban (2) Compact | Urban Single-Lane | Urban Double-Lane | Rural Single-Lane | Rural Double-Lane |
|---|---|---|---|---|---|---|---|
| General | Number of Lanes | 1 | 1 | 1 | 2 | 1 | 2 |
| | Typical max. (3) ADT | 12,000 | 15,000 | 20,000 | 40,000 | 20,000 | 40,000 |
| | Splitter Island Treatment | Painted, raised if possible | Raised | Raised | Raised | Raised extended | Raised extended |
| | Max. Design(4) Vehicle | SU | SU/BUS | WB-50 | WB-50 | WB-67 | WB-67 |
| Circulating | Inscribed Circle Diameter | 45'-80' | 80'-100'(5) | 100'-130'(6) | 150'-180' | 115'-130'(6) | 180'-200' |
| | Circulatin Roadway Design Speed | 15-18 mph | 16-20 mph | 20-25 mph | 22-28 mph | 22-27 mph | 25-30 mph |
| | Circulating Roadway Width | 14'-19' | 14'-19' | 14'-19' | 29'-32' | 14'-19' | 29'-32' |
| Entry | Max. Entry Design Speed | 15 mph | 15 mph | 20 mph | 25 mph | 25 mph | 30 mph |
| | Entry Radius | 25'-45' | 25'(7)-100' | 35'(7)-100' | 100'-200' | 40'(7)-120' | 130'-260' |
| | Entry Lane Widths | 14'-16' | 14'-16' | 14'-16' | 25'-28' | 14'-16' | 25'-28' |

(1) Mini roundabouts are not suitable for use on a state route.

(2) Urban compact roundabouts are normally not suitable for use on a state route.

(3) Total ADT entering a 4-leg roundabout with 33% of the volume on the minor roadway. Multiply by 1.2 for 4-leg roundabouts with equal volume on both roadways. Multiply by 0.9 for 3-leg roundabouts.

(4) See Chapter 910 for selecting a design vehicle on a state route.

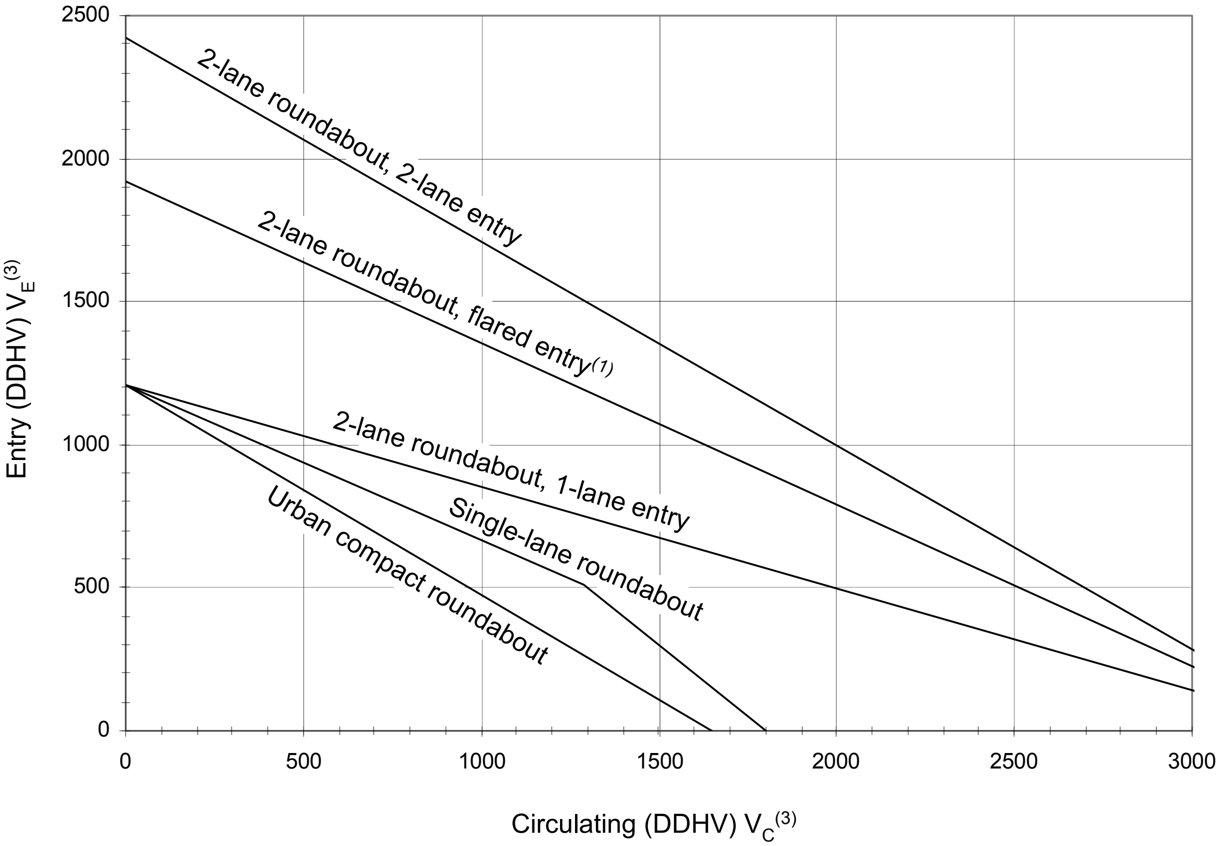
(5) Use 100 ft minimum on state routes.

(6) When roundabout might be expanded to a double-lane roundabout, consider using a double-lane roundabout diameter.

(7) Use 50 ft minimum on state routes.

Note:
The values given in this figure are approximate. They are intended for planning and preliminary design. Final design values may vary.

**Roundabout Categories Design Characteristics**
*Figure 915-7*

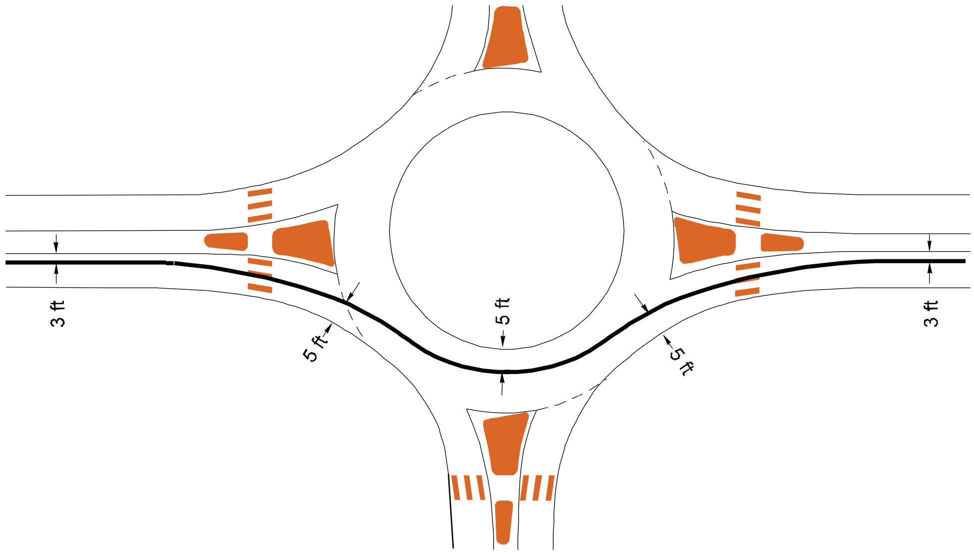




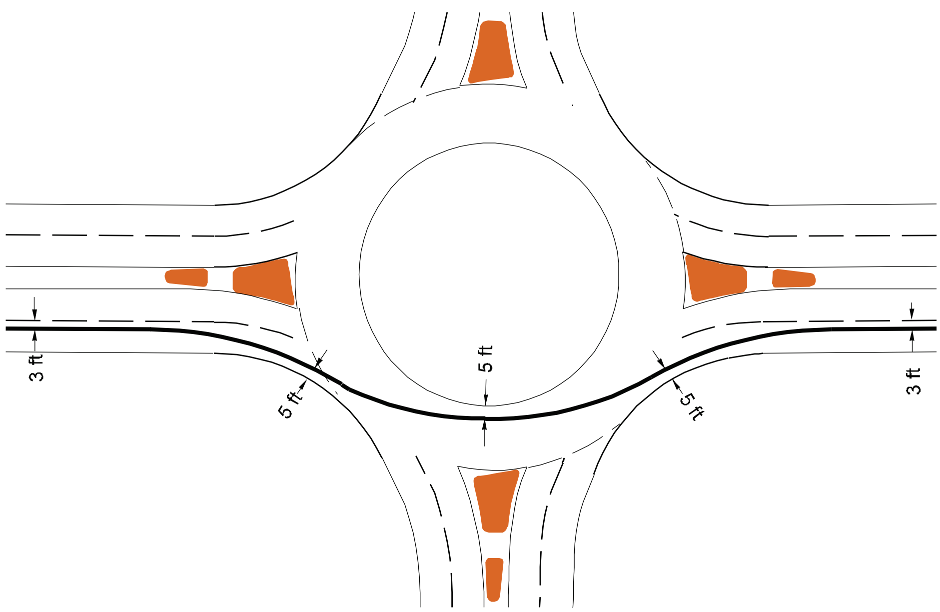
Note:
(1) Entry flared with 2 vehicle storage lane.
(2) Check for each entry.
(3) DDHV in passenger car equivalents.

| Vehicle Type | Passenger Car Equivalent |
|---|---|
| Car | 1.0 |
| SU or BUS | 1.5 |
| Other truck | 2.0 |
| Bicycle or Motorcycle | 0.5 |

**Approximate Entry Capacity**
*Figure 915-8*

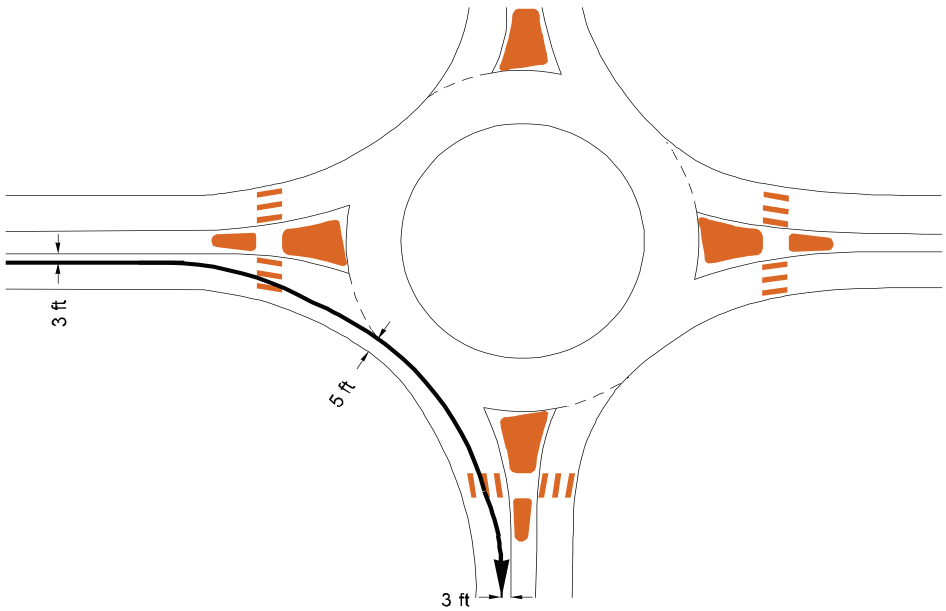



**Single-Lane Roundabout**

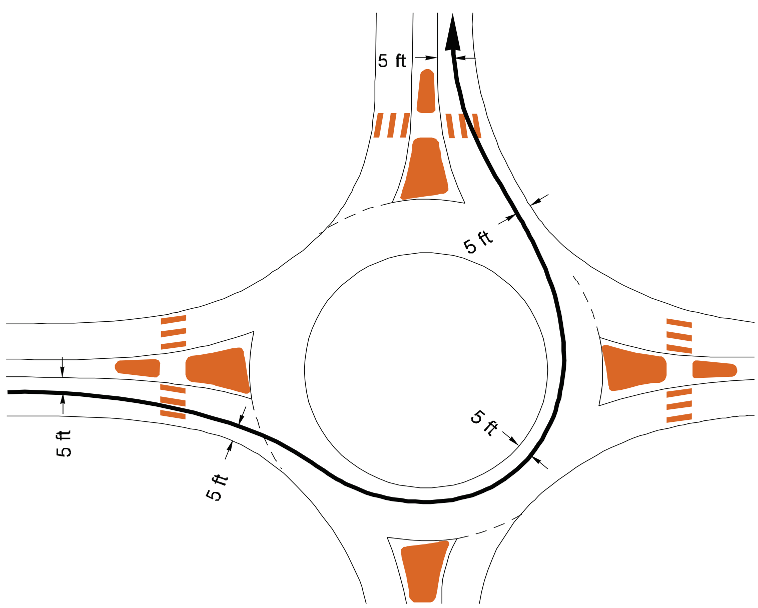



**Double-Lane Roundabout**

**Deflection Path**
*Figure 915-9a*

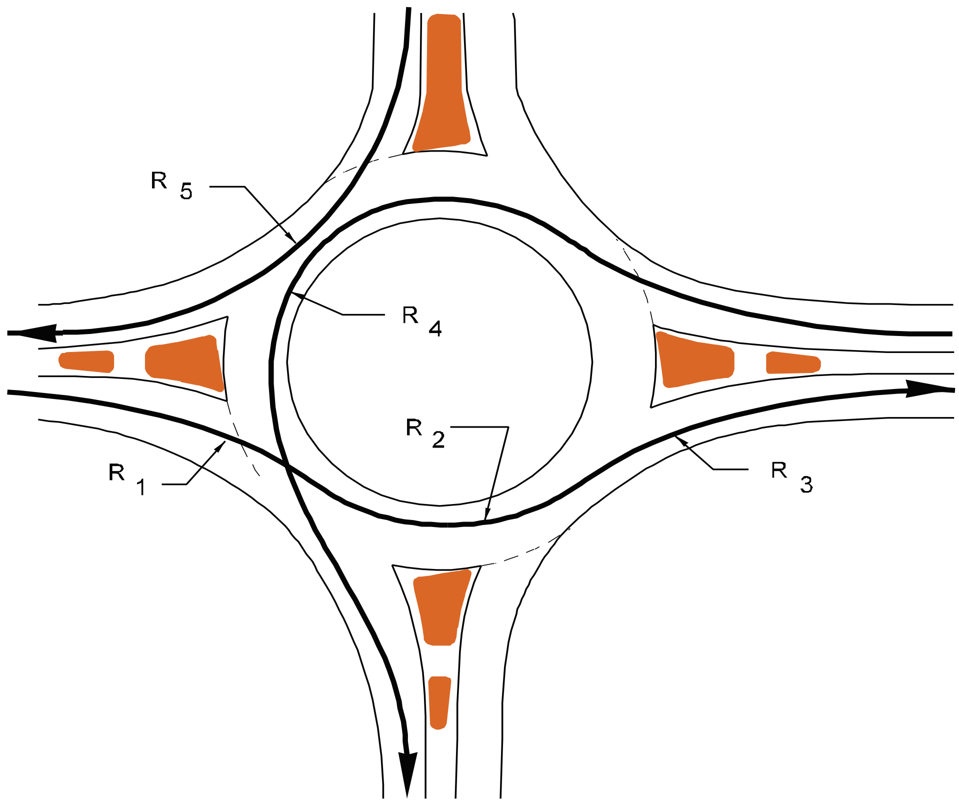



**Right-Turn Movement**




**Left-Turn Movement**

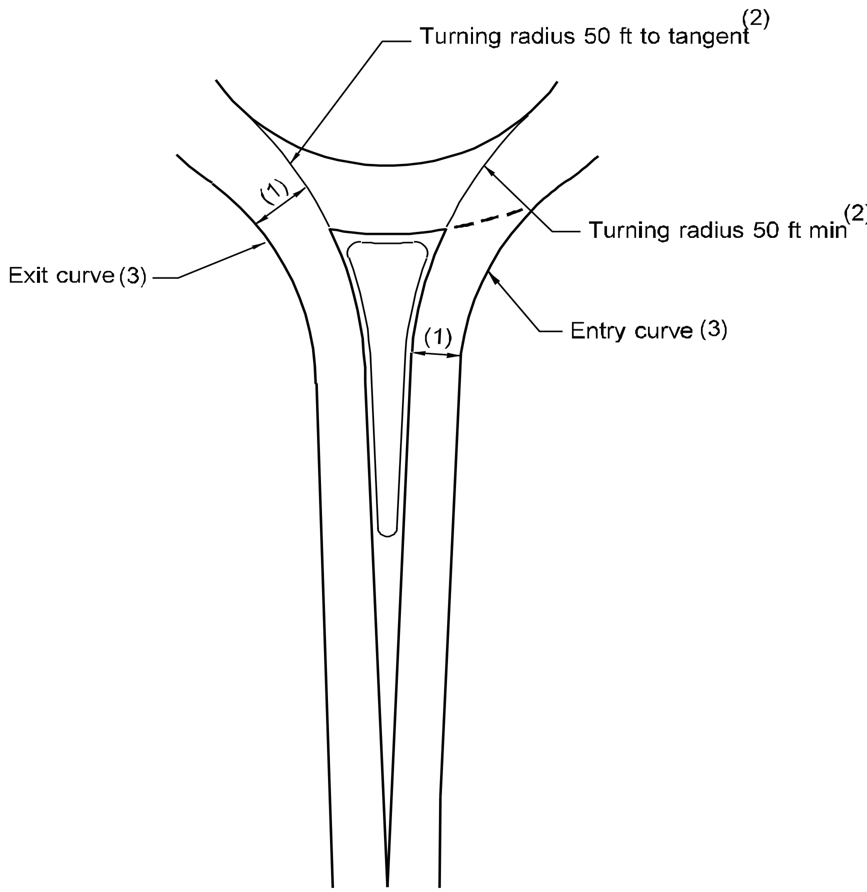
**Deflection Path**
*Figure 915-9b*




Where:

$R_1$ = entry path radius.
$R_2$ = circulating path radius.
$R_3$ = exit path radius.
$R_4$ = left-turn path radius.
$R_5$= right-turn path radius.

**Deflection Path Radius**
*Figure 915-10*



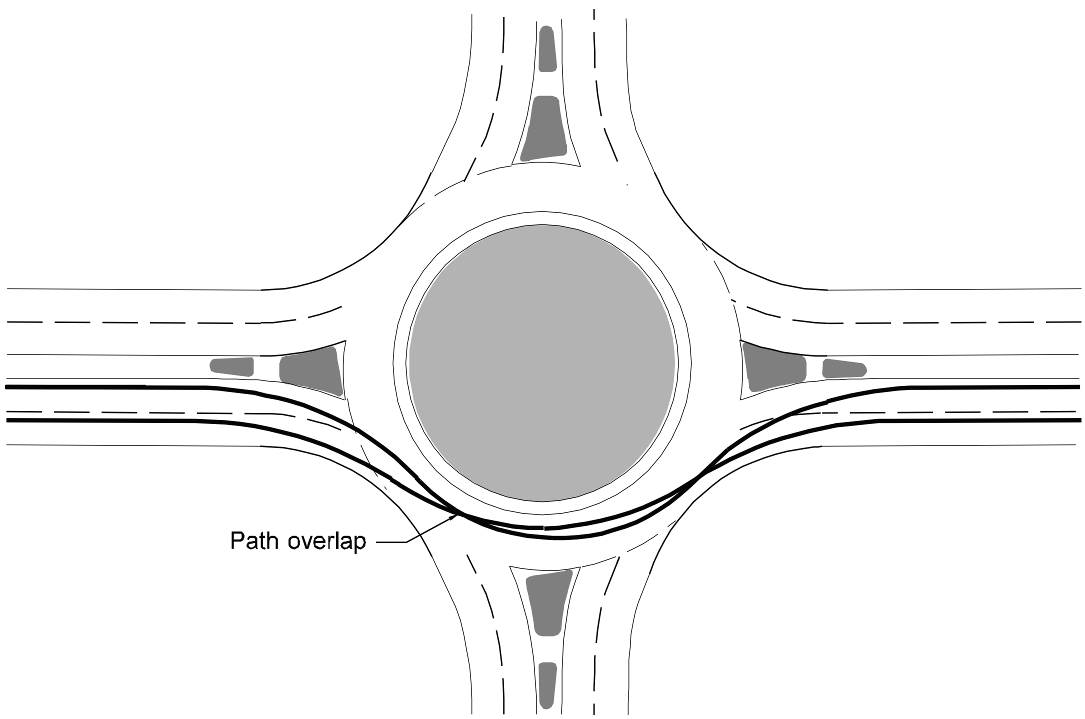

Notes:

(1) Minimum width is 15 ft for 1-lane and 25 ft for 2-lane. Entry and exit widths based on capacity needs (see Figure 915-8) and design vehicle requirements (see Chapter 640 or use templates).

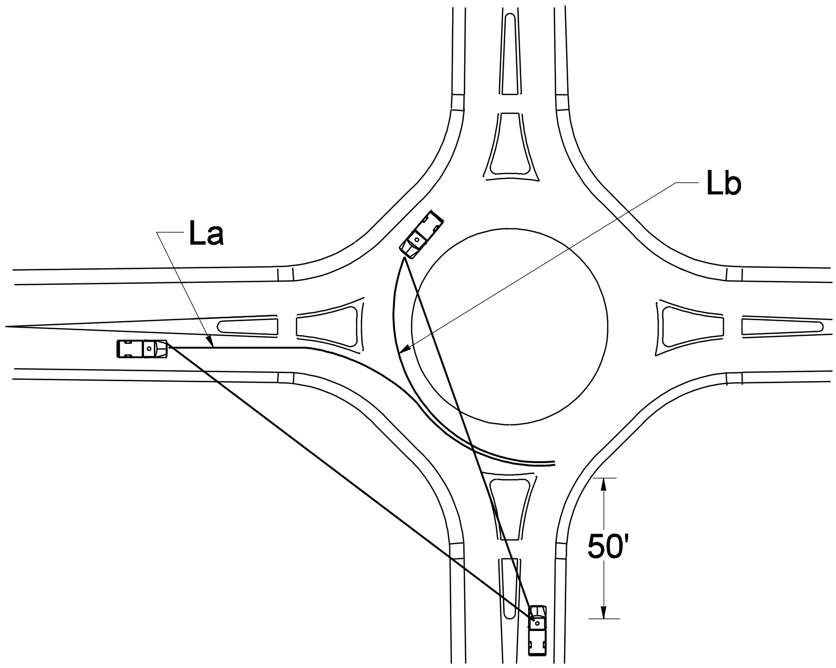
(2) Continuation of splitter island envelope curve tangential to central island.

(3) Entry and exit curves tangential to outside edge of circulating roadway.

**Entry and Exit**
*Figure 915-11*




**Path Overlap**
*Figure 915-12*




| Speed (mph) | Gap Acceptance Length (min), L (ft) |
|---|---|
| 15 | 115 |
| 20 | 150 |
| 25 | 185 |
| 30 | 225 |
| 35 | 260 |

Where:

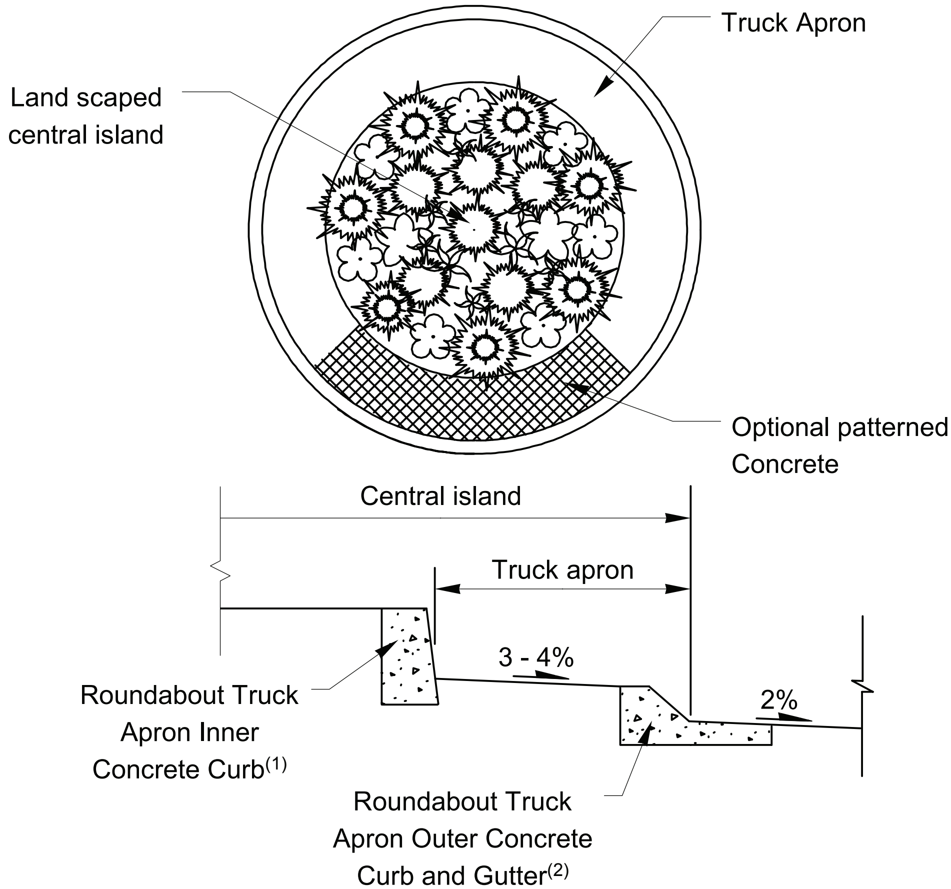
La = Sight distance, measured from the yield point, along approach roadway to the left, the minimum gap acceptance length (L) using the average of the entry speed ($R_1$) and the circulating speed ($R_2$).

Lb = Sight distance, from the yield point, along the circulating roadway, the minimum gap acceptance Length (L) using the left-turning vehicle speed ($R_4$).

Note:

See 915.06(2) and Figures 915-9a and 9b for information on determining $R_1$, $R_2$, and $R_4$ speeds.

**Roundabout Intersection Sight Distance**
***Figure 915-13***

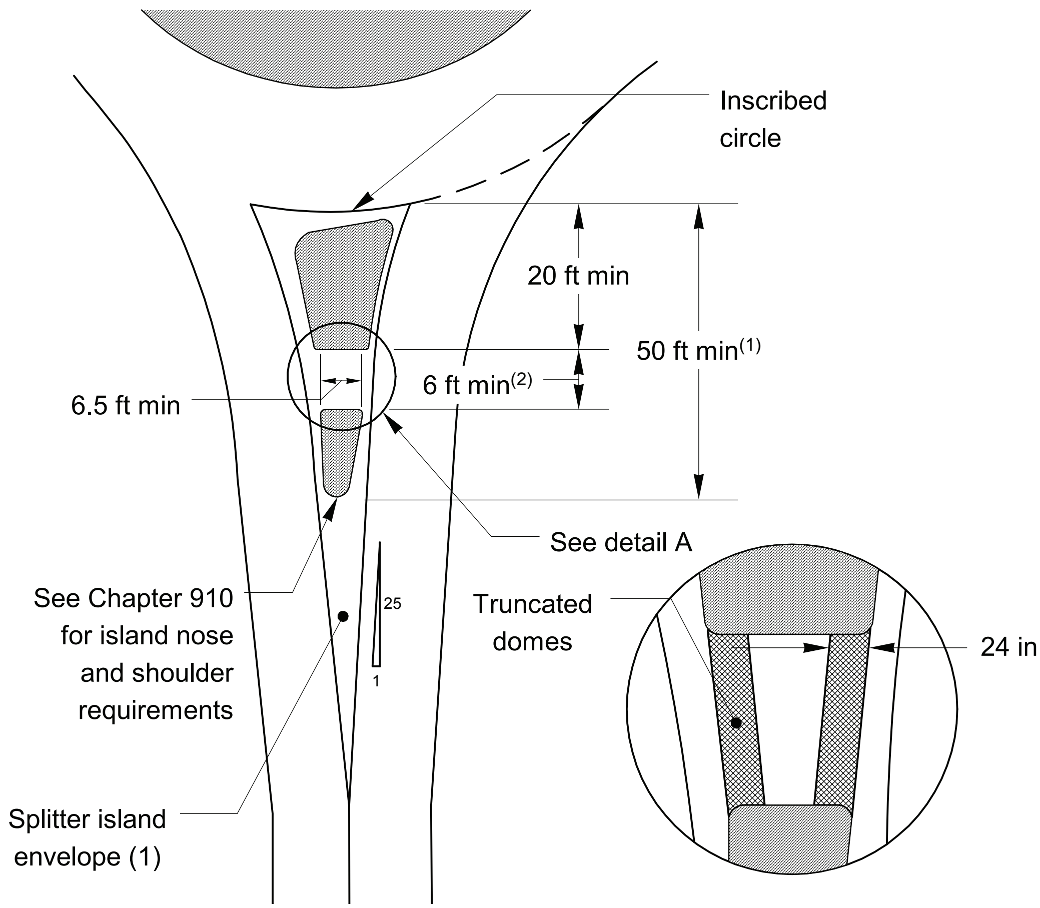



Notes:

(1) See Standard Plans for Roundabout Truck Apron Inner Concrete Curb details.

(2) See Standard Plans for Roundabout Truck Apron Outer Concrete Curb details. Other mountable curbs, with a maximum height of 3 in, may be used.

**Central Island**
***Figure 915-14***

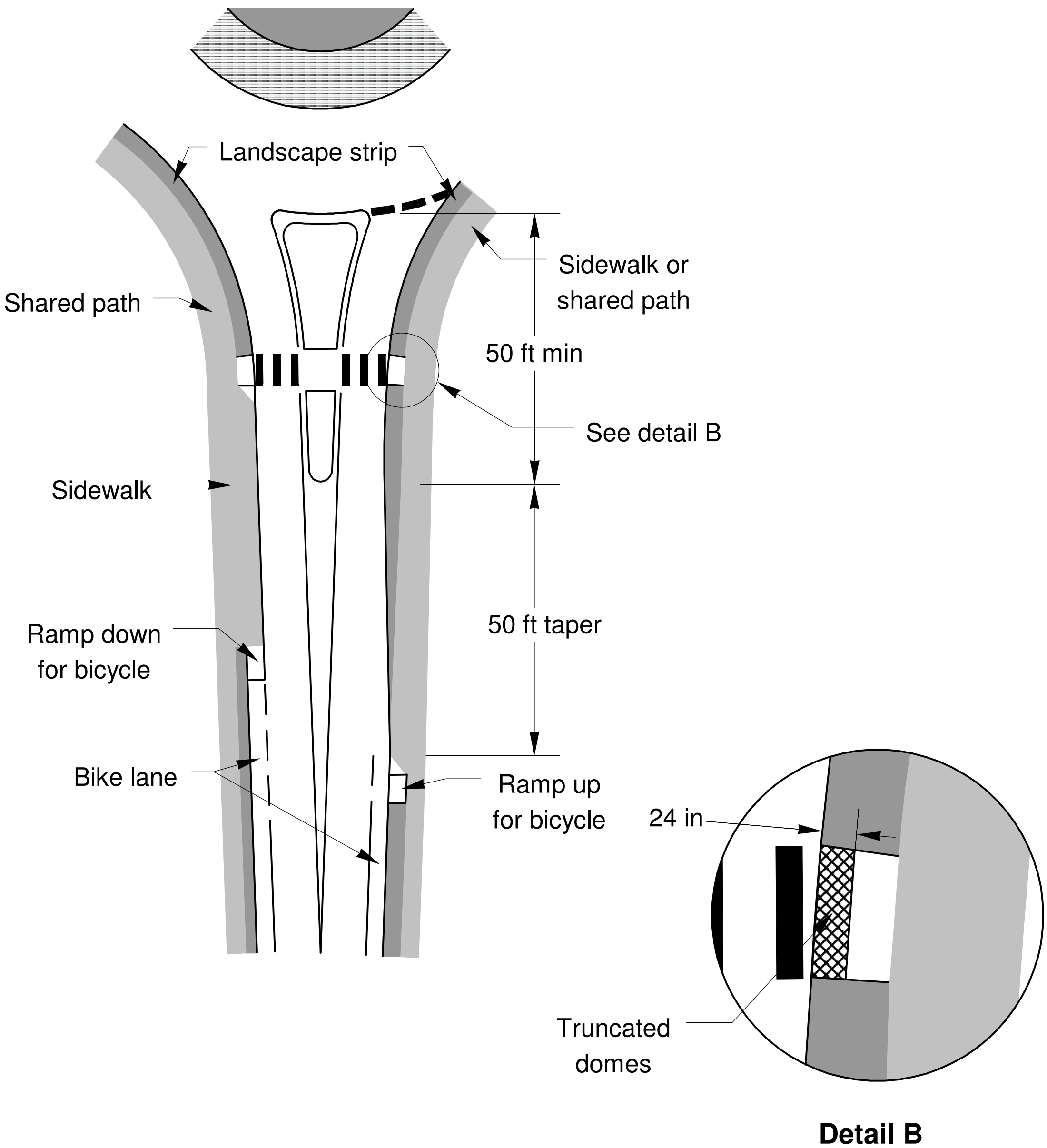



Notes:

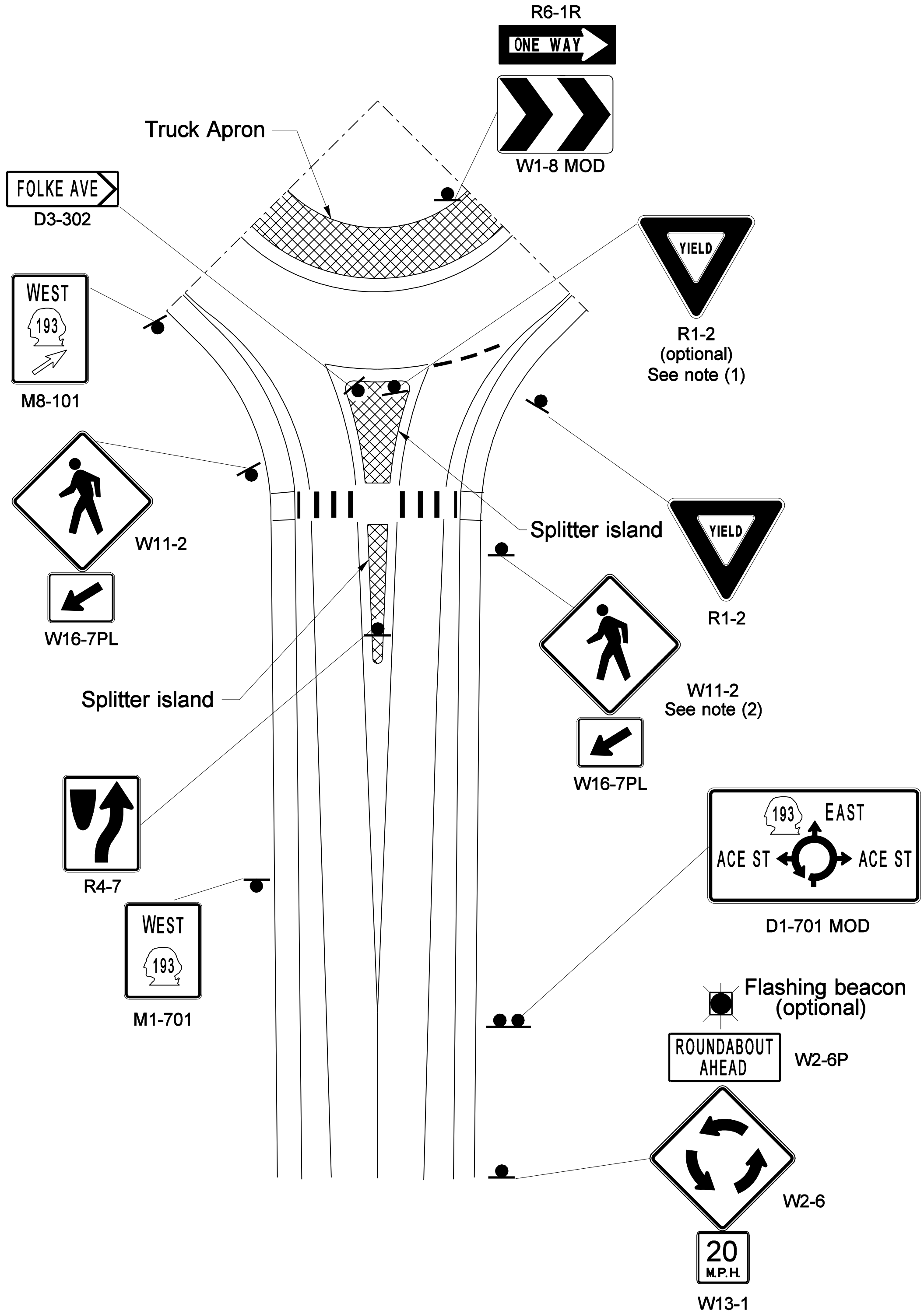
(1) Stopping sight distance desirable for length of splitter island envelop.

(2) A 10 ft width to accommodate full crosswalk width is desirable.

**Splitter Island**
*Figure 915-15*




**Shared Use Sidewalk**
*Figure 915-16*



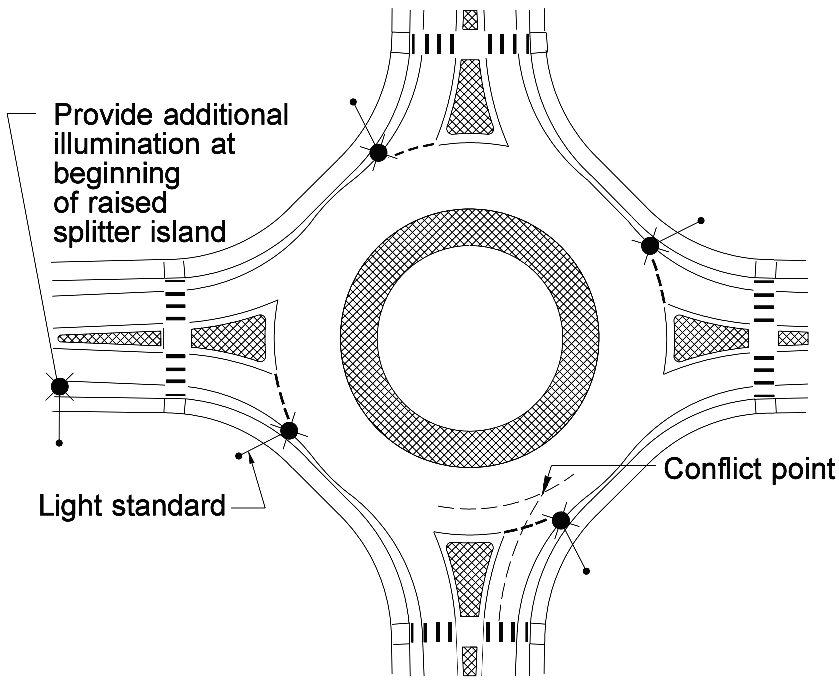

Notes:

(1) Required on two-lane entries, consider when view of right side sign might become obstructed.

(2) Locate in such a way as to not obstruct view of yield sign.

(3) See Chapter 820 for additional information on sign installation.

**Roundabout Signing**
***Figure 915-17***




Note:

Consider additional lighting for walkways and crosswalks to provide visibility for pedestrians.

**Roundabout Illumination**
*Figure 915-18*